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TOBACCO HORNWORM INSECTICIDE

RECOMMENDATIONS FOR USE OF POWDERED ARSENATE OF LEAD IN DARK-TOBACCO DISTRICT

FROM the time when tobacco was first cultivated in the dark-tobacco regions of Tennessee and Kentucky it has been necessary to combat the hornworms in order to produce profitable crops. For many years the practice of removing them from the plants by hand was followed. Later Paris green came into general use. This bulletin deals with the use of powdered arsenate of lead, which has been found to be preferable to Paris green in many respects. Full directions for its use under varying conditions are given.

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TOBACCO HORNWORM INSECTICIDE:

RECOMMENDATIONS FOR USE OF POWDERED ARSENATE OF LEAD IN DARK-TOBACCO DISTRICT.

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TOBACCO HORNWORMS[1] are the everpresent and most serious pests of tobacco in Tennessee and Kentucky. Without control measures no tobacco could be grown. When labor was cheap and plentiful, hand-worming as a means of control was fairly satisfactory, but with the increasing scarcity, cost, and inefficiency of hand labor this method had to be abandoned and the tobacco growers were forced to use an insecticide or cut down the acreage. About 20 years ago, when insecticides were first employed, Paris green was found to be the safest and most efficient. Nevertheless, there has always been serious objection to its use on account of the very frequent serious burning of tobacco, which reduced the value of the crop frequently as much as 5 per cent and occasionally by as much as from 10 to 25 per cent. To find a safe and efficient insecticide has been one of the main lines of investigation at one of the field laboratories of the United States Bureau of Entomology in Tennessee. As a result of the present investigation the diplumbic form of arsenate of lead was found to meet all requirements.

During the past several years tobacco growers in the "Black Patch" have used many tons of arsenate of lead upon tobacco, and from the reports of satisfaction received it is very evident that its use will be increased during the succeeding years; accordingly, for the benefit of those who will use arsenate of lead for the first time, as well as for those who have begun its use recently, it has been thought advisable to set forth a comparison of results obtained by farmers in 1916 with both Paris green and arsenate of lead with the results obtained by agents of the bureau from arsenate of lead experiments, that tobacco growers may know, from actual records, what to expect in following the bureau recommendations.

[1] *Protoparce sexta* Joh. and *P. quinquemaculata* Haw.; order Lepidoptera, family Sphingidæ.

ADVANTAGES IN THE USE OF ARSENATE OF LEAD.

Hand-worming, as has been stated, is impossible upon a large scale because of the scarcity of labor, its relatively high cost, and its general inefficiency. Under average conditions of infestation hand-worming will cost at least $10 an acre, and even with this amount of labor, damage by worms can not be prevented entirely, for the most vigilant wormer will overlook many worms. On the other hand a thorough application of arsenate of lead will be effective for a period of at least 10 days following the application, and under favorable conditions will keep the tobacco clean for that period. The records at hand do not show that Paris green can be expected to exert satisfactory control for a period longer than from five to seven days. Arsenate of lead adheres to tobacco longer than does Paris green, and rarely does it cause any burning of the plant. The authentic cases of injury by arsenate of lead have been so few, and the attendant damage so slight, as compared with that caused by Paris green, that the probability of damage is not considered by farmers who have used arsenate of lead long enough to become thoroughly familiar with its action.

In addition to its longer period of effectiveness and the greater safety to the plant, arsenate of lead is not now much more costly per application than is Paris green, and when the longer period of effectiveness is considered it is the more economical. This poison is also very much less irritating to the skin than is Paris green and, so far, there has been no complaint of its having produced sores upon workmen who applied it.

SOME EARLY TESTS OF ARSENATE OF LEAD IN COMPARISON WITH PARIS GREEN.

APPLICATIONS IN FAIR WEATHER.

On August 24, 1910, Paris green was applied to a plat of tobacco at the rate of 1½ pounds per acre. On the third day after the application 95 per cent of the worms were dead. On the fifth day after the application, however, numbers of small worms were seen working upon the tobacco, which indicated that the dosage was losing its effect. On August 25, 1910, powdered arsenate of lead was applied, in the same field, to one plat at the rate of 5 pounds per acre and to another plat at the rate of 3½ pounds per acre. On the fourth day after the application about 99 per cent of the worms had been killed by the 5-pound dosage and about 89 per cent by the 3½-pound dosage. Both dosages of lead arsenate continued to kill the worms for several days after the Paris green had lost its effect.

The foregoing applications were made under the most favorable conditions; that is, when the dew was on the plants and when there was no breeze. The tobacco was about two-thirds grown.

On August 21, 1911, arsenate of lead at the rate of 4⅜ pounds per acre was applied during a breeze. At the expiration of four days only 78 per cent of the worms were dead. On the same date and under the same conditions an application of Paris green at the rate of 1¾ pounds per acre killed only 54 per cent of the worms in four days. These experiments emphasize the necessity of making the application of an insecticide when there is very little breeze.

APPLICATIONS IN RAINY WEATHER.

On August 28, 1911, arsenate of lead was applied about 7 a. m. to two plats of tobacco at the rate of 5 pounds and 4 pounds per acre, respectively, and Paris green was applied to the check plat at the rate of 2½ pounds per acre. The same day between 11 a. m. and 2 p. m. about one-third of an inch of rain fell in dashing showers. On the second day after the application 91 per cent of the worms had been killed by the 5-pound dosage of arsenate of lead, 83 per cent by the 4-pound dosage of arsenate of lead, and only 66 per cent by the 2½-pound dosage of Paris green. On the fourth day after the application the number of worms on the 5-pound dosage arsenate of lead plat was still further reduced. On the other hand, the worms had increased in numbers upon the 4-pound dosage arsenate of lead plat and on the Paris-green plat. These results indicate that arsenate of lead can be made effective under conditions in which Paris green is practically a failure.

EXPERIMENTAL ACRE AT CLARKSVILLE, TENN.

During the summer of 1913 an experimental acre of tobacco at Clarksville, Tenn., was kept free of worms by the use of powdered arsenate of lead from the time worms appeared in destructive numbers until worms ceased to appear. Four applications were made, a total of 12¼ pounds being used, an average of a little more than 3 pounds per dosage. The first dosage, only 2½ pounds, was too light, however, and it had to be repeated. Had the first dosage been at the rate of about 4 pounds per acre, undoubtedly two more dosages of about 3½ pounds per acre would have been sufficient to do the work accomplished by the four applications. The total cost of the arsenate of lead and labor (assuming the arsenate of lead to retail at 25 cents per pound) was $3.86, an average cost of 77 cents per week for the five weeks over which the dosages remained effective.

The first dosage was applied while the worms were small, and the repetition of the dosages at intervals of about 10 days prevented the growth of large worms. No hand worming was done upon this acre and no tobacco was injured either by the worms or by the arsenate of lead.

COMPARISON OF RESULTS OBTAINED BY THE USE OF PARIS GREEN AND ARSENATE OF LEAD IN 1916 IN KENTUCKY AND TENNESSEE.

In the year 1916 records of the results obtained from dust applications of both Paris green and arsenate of lead, by farmers in several counties in Kentucky and Tennessee, were made to determine the relative efficiency of these two insecticides.

On the 92 fields upon which they had applied Paris green at the average rate of 1.31 pounds per acre, 22.7 per cent of the worms were found dead 9 days after the application. On 108 fields upon which they had applied arsenate of lead at the average rate of 3.2 pounds per acre, 48.14 per cent of the worms were found dead 13 days after the application.

No better comment could be made upon the comparative insecticidal values of Paris green and arsenate of lead than the foregoing statement of results, particularly so when it is considered that the average dosage of Paris green was as large as could be applied with reasonable safety and that the dosage of arsenate of lead could have

been doubled without causing any serious damage to the tobacco plants.

Although an examination of these fields three to five days after the applications undoubtedly would have shown that the hornworms were being killed in considerable numbers in many instances, yet it would have shown also that the fields were not being kept free of worms. The records show also that with a light dosage of arsenate of lead more than twice as many worms were being killed as with the usual dosage of Paris green.

Table 1 shows the average results of the best fourth of the field records mentioned above.

TABLE 1.—*Comparison of applications of Paris green and arsenate of lead made by farmers in Kentucky and Tennessee, using the best fourth of the records of each.*

Poison used.	Average number of days from application to examination.	Average dosage per acre.	Hornworms killed.	Number of fields recorded.
		Pounds.	*Per cent.*	
Paris green	5¼	1¼	47.1	23
Arsenate of lead	4¼	4¼	83.3	27

The foregoing comparison of the best results obtained by farmers brings out two facts very clearly: First, farmers, on the average, are not keeping tobacco free of hornworms in a satisfactory manner with Paris green; second, they are securing much better results with arsenate of lead than with Paris green.

Before discussing the dosage of arsenate of lead required under different conditions it will be well to compare the results obtained by farmers with arsenate of lead with results obtained through field applications made by agents of this bureau.

RESULTS OF FARMERS' APPLICATIONS OF ARSENATE OF LEAD VERSUS RESULTS OF APPLICATIONS MADE BY BUREAU AGENTS.

Table 2 compares the results obtained by agents of this bureau with results obtained by farmers upon the 27 fields recorded in Table 1.

TABLE 2.—*Comparison of the best fourth of farmers' applications of arsenate of lead with the best fourth of the applications of the same insecticide made by agents of the bureau.*

Applied by—	Number of days from application to examination.	Average dosage per acre.	Hornworms killed.	Number of fields recorded.
		Pounds.	*Per cent.*	
Farmers	4⅛	4⅛	83.3	27
Bureau agents	3⅜	5 1/10	88.6	25

The farmers' application of 4⅛ pounds per acre killed 5 per cent less worms in 4⅛ days than were killed by the application of 5 1/10 pounds per acre by agents of the bureau in 3⅜ days. Both dosages did good work, but there is considerable advantage in favor of the 5 1/10 pound dosage. Table 2 does not show a very great advantage in favor of the 5 1/10 pound dosage as compared with the dosage of 4⅛ pounds, but something of the lasting effects of large dosages must be

learned before a proper conclusion can be drawn. Table 3 shows the lasting results of a large dosage very plainly. The examinations of the experiments by agents of this bureau were made at periods varying from 8 to 15 days after the applications, and are compared with examinations made 9 to 12 days after applications by farmers. The average period between application and examination will be seen to be practically the same. The tobacco was full grown, promising an average yield of 800 pounds per acre.

TABLE 3.—*Results of examinations made at the expiration of an average of 10 days after applications of arsenate of lead made by agents of this bureau and by farmers.*

Applied by—	Average examination period.	Number of fields examined.	Average dosage.	Hornworms found dead.
	Days.		*Pounds.*	*Per cent.*
Agents	10.3	10	5.1	72.6
Farmers	10.0	16	4.0	31.0

The results in Table 3 show conclusively that a 4-pound dosage can not be expected to keep tobacco even approximately clean for a period of 10 days, and that a dosage of 5 pounds will kill a great many worms in 10 days, since the examinations of the 5-pound dosage showed nearly 2½ times as many dead worms as in the case of the 4-pound dosage. It is very evident that large tobacco must be given at least a 5-pound dosage if it is to be kept reasonably free of worms for more than a few days.

DOSAGE OF ARSENATE OF LEAD REQUIRED.

The foregoing records were all taken from fields upon which only one dosage of lead arsenate was applied. The tobacco was practically full grown and, as a rule, was infested heavily with hornworms, many of which were half grown or larger; under such conditions a 5-pound dosage of arsenate of lead is absolutely necessary. It is better, however, not to rely upon one application to keep tobacco clean, for one good application can not be expected to do satisfactory work, under average conditions, for more than 10 days. Therefore, in seasons during which the moths deposit eggs in considerable numbers over a period much greater than 10 days, another dosage of an insecticide must be applied or the worms must be hand-picked.

AT LEAST TWO DOSAGES RECOMMENDED.

Under usual conditions in the "Black Patch" in Kentucky and Tennessee at least two dosages should be given. The size of the dosages must be governed by the size of the worms. If the worms are small and the tobacco is not more than half grown, a 3½-pound dosage per acre, evenly applied, will be sufficient. This may be followed by a dosage of from 3½ to 4 pounds when small worms again appear in any considerable numbers. If, on the other hand, worms are large at the time of the first application, not less than from 4 to 4½ pounds per acre should be applied. If the tobacco is large, 5 pounds per acre should be used. The time and necessity for a second dosage must be determined by an examination of the fields at intervals of two or three days after the first application, and the size of the dosage should be governed by the size of the tobacco and number of worms.

Table 4 will furnish a good working basis for applications of arsenate of lead in most cases.

TABLE 4.—*A working basis for applications of powdered arsenate of lead for general use.*

Size of tobacco.	Size of worm.	Powdered arsenate of lead per acre.
		Pounds.
Half grown or less	Small	3½
Do	Large	4 to 4½
Half grown to full grown	Small	4
Do	Large	4 to 5
Full grown	Small	4 to 4½
Do	Large	5 to 6

HOW TO APPLY ARSENATE OF LEAD TO TOBACCO.

In order to insure proper application of arsenate of lead to tobacco, it is imperative that proper machinery be secured. Therefore use only such hand dusters as are especially adapted for distributing arsenate of lead.

It is important to use a powerful dust gun and to make a thorough and even application. Do not attempt to apply any dust poison during a strong breeze. Absolute calm is to be preferred and the best applications can be made only under that condition. Make dust applications early in the morning or late in the afternoon when the air is still or there is at most only a slight breeze. Thoroughness and evenness of application can not be emphasized too strongly, for an uneven application made in a strong breeze will leave enough live worms to damage the tobacco seriously.

WHEN TO APPLY ARSENATE OF LEAD.

The first application should be made when worms become too numerous to be kept off tobacco easily by the hand-picking that is usually done while hoeing, suckering, or topping. Many farmers make only one application, and that at a time when worms are numerous and many of them half grown or larger. It is better to make more than one application, the first one being applied as recommended. The time for repeating the application can be determined by the number of eggs and young worms appearing upon the tobacco. Worms should be killed during the first week after hatching, for during the second and third weeks they are much harder to kill and they will eat many times as much tobacco as is consumed during the first week.

GRADE OF ARSENATE OF LEAD THAT SHOULD BE USED.

Arsenate of lead may be divided, broadly, into two forms, triplumbic and diplumbic. Theoretically the triplumbic form may contain 25.58 per cent of arsenic oxid, while the diplumbic may contain 33.15 per cent of arsenic oxid. Experiments have shown that the triplumbic form is too slow in its insecticidal action to justify its use against tobacco hornworms. The diplumbic form is the one that should be used. *In order to be sure of receiving the diplumbic form, demand that the manufacturer and dealer guarantee that the arsenate of lead you buy contains at least 30 per cent of arsenic oxid* (As_2O_5) *of which not more than 1 per cent is free, or water-soluble.* This grade was the

one used in all the experiments mentioned in this bulletin. It is necessary to have a low percentage of free, or water-soluble, arsenic in order to insure against burning the tobacco. It is also necessary to use only those grades having a density of from 80 to 100 cubic inches per pound in order to secure proper dusting qualities.

COST OF ARSENATE OF LEAD.

From 1915 to 1922 powdered arsenate of lead suitable for use upon tobacco retailed at prices ranging from 16 to 30 cents per pound. The 16-cent price prevailed in a few localities in 1922. By clubbing together farmers may find it possible to buy somewhat cheaper direct from the factory. At 25 cents per pound the first application of powdered arsenate of lead will cost from 87½ cents to $1 per acre, and the 5-pound dosage recommended for large tobacco will cost $1.25. With Paris green, a 1½-pound dosage would cost from 60 to 80 cents, and a 2-pound dosage would cost from 80 cents to $1. At present, therefore, it is apparent that arsenate of lead is almost as cheap as Paris green, and when its greater lasting qualities are taken into consideration it is cheaper.

CALCIUM ARSENATE.

Calcium arsenate is somewhat cheaper than arsenate of lead, and its insecticidal action is satisfactory when used in approximately as heavy dosages as arsenate of lead. But since experiments show considerable burning of tobacco its use is not recommended.

SUMMARY.

Paris green, although an effective insecticide, frequently burns tobacco very severely and may reduce the value of the crop by as much as 50 per cent in exceptional cases.

Arsenate of lead never seriously injures tobacco even under the most unfavorable conditions.

A dosage of Paris green large enough to be effective against hornworms can not be applied without grave danger of burning tobacco.

Calcium arsenate, although safer than Paris green, is more likely to burn tobacco than is arsenate of lead, and its use is not recommended.

Paris green, which is applied in dust form without a carrier, is used at the rate of from 1 to 2 pounds per acre.

Arsenate of lead is safe and effective during rainy weather, whereas Paris green is dangerous and ineffective.

It is recommended that arsenate of lead be used against the tobacco hornworms and that it be applied as a dust or powder.

The dosage of arsenate of lead in powdered form varies from 3½ pounds to 5 pounds per acre. If applied as a spray, use from 3 to 4 pounds in 100 gallons of water.

Use only such dust guns as are especially adapted for applying arsenate of lead.

Apply arsenate of lead when there is no breeze and when dew is on the plants.

Use only such brands of arsenate of lead as are guaranteed to contain at least 30 per cent of arsenic oxid, of which not more than 1 per cent is free, or water-soluble, and that have a density of from 80 to 100 cubic inches per pound.

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